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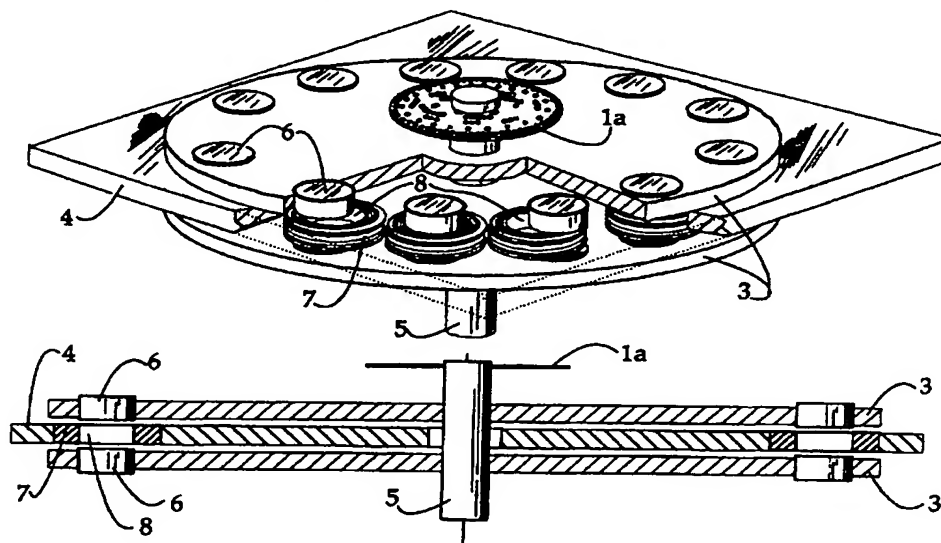
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/US95/17031 (22) International Filing Date: 29 December 1995 (29.12.95) (71) Applicant: H.E.F.O., INC. [US/US]; Suite H, 1235 Hotel Circle South, San Diego, CA 92108 (US). (72) Inventors: GOSSLER, Scott, E.; 2331 Palermo Drive, San Diego, CA 92106 (US). MURRAY, Eugene, R.; 6521 Lochmoor Drive, San Diego, CA 92120 (US). (74) Common Representative: H.E.F.O., INC.; Murray, Eugene, R., Suite H, 1235 Hotel Circle South, San Diego, CA 92108 (US).</p>		<p>(81) Designated States: AL, AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report.</p>

(54) Title: HIGH EFFICIENCY DC MOTOR WITH GENERATOR AND FLYWHEEL CHARACTERISTICS

(57) Abstract

A high efficiency multiphasic type DC motor incorporating brushless electronic switching to phase the attractive and repulsive forces between the permanent magnets (6) in the rotor (3) and wire wound air core coils (7) in the stator (4). The unequal number of magnets (6) and coils (7) provides a designed imbalance, so that proper energization induces rotation and torque in the motor's dual flywheel rotor (3). Electronic switching collects inductive kickback and back emf simultaneously during the motor phase and in addition, disconnects the attraction and repulsion phases during regenerative braking, etc. and directs



all this generated power back to the power pack (2) where it is stored in batteries and capacitors. The rechargeable batteries (2) and capacitors in the power pack (2) are the source of operating electrical power for the motor. The rotating assembly is designed to have adequate mass so that the kinetic energy of rotation smooths out the pulsing moments introduced by the attraction and repulsion of the coils (7) and magnets (6) and to ensure continuous rotation of the dual flywheel rotor (3). The combination of electronic switching, the low hysteresis loss in the air core coils (7), the streamlined configuration of the rotor (3) which reduces windage loss and the recovery of the generated currents in the air core coils (7) contribute to the high efficiency of the electric DC motor.

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1 HIGH EFFICIENCY DC MOTOR WITH GENERATOR AND
2 FLYWHEEL CHARACTERISTICS

3
4 BACKGROUND OF THE INVENTION

5
6 1. Field of the Invention

7 This invention is concerned with a high efficiency, multiphasic
8 DC motor, with rotor flywheel, that operates with generator and
9 flywheel characteristics, that simultaneously captures and stores
10 inductive kickback and back emf, in addition to collecting other
11 generated power such as regenerative braking. The motor has an
12 efficiency of about 80% at 100 RPM rising to 95% at 3000 RPM. It is
13 pancake shaped with sufficient mass in the dual rotors to store
14 kinetic energy as a flywheel. Twelve permanent magnet pairs are
15 mounted in the periphery of the dual rotors and fifteen air core coils
16 are in the periphery of the stator, which is a designed imbalance that
17 positions adjoining magnets at different degrees of distance from the
18 coils ahead and the coils behind. The inductive kickback, back emf
19 and other generated power are stored for future use in a power pack
20 of rechargeable batteries and capacitor banks. Torque and RPM are
21 controlled and varied by a microprocessor and algorithm.

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23 2. Description of the Related Art

24
25 A. U.S. Patent No. 4,330,742 to Reimers May 18, 1982 "Circuitry for
26 Recovering Electrical Energy with an Electric Vehicle DC Propulsion
27 Motor When Braking" describes a DC propulsion motor for a vehicle
28 that becomes a generator by using the motor's kinetic energy when
29 the vehicle is braked. U.S. Patent No. 4,055,789 to Lasater October
30 25, 1977 for "Battery Operated Motor With Back EMF Charging"
31 describes a motor driven by electric current from a charged battery
32 during a first time interval. During a second time interval the
33 charged battery is disconnected and a discharged battery is
34 connected to the motor, which is operating as a generator as it winds
35 down. U.S. Patent No. 3,890,548 to Gray June 17, 1975 for a "Pulsed
36 , Capacitor Discharge Electric Engine" describes a motor that uses

37 stepped-up transformer current from batteries to charge capacitors,
38 which are discharged across a spark gap through stator and rotor
39 coils, generating motion by magnet repulsion. The discharge
40 overshoot, inductive kickback, from collapsing fields in the coils is
41 then used to energize, charge, external batteries for conservation of
42 power. U.S. Patent No. 4,785,228 to Goddard Nov. 15, 1988 "Electrical
43 Energy Enhancement Apparatus" describes a generator device driven
44 by an externally operated motor that uses a flywheel and gyroscope
45 in the motor to store energy. Patent No. 4,629,947 to Hammerslag et
46 al Dec. 16, 1986 "Electric Vehicle Drive System" describes an electric
47 vehicle power system that uses a battery to drive electric drive
48 motors, a flywheel to drive a generator during peak loads and a
49 microprocessor to control the system, with the battery and flywheel
50 recharged during deceleration or braking, or by a charger when idle.

51 DC motors that individually capture, collect, store and use all
52 forms of generated power, inductive kickback, back emf and
53 regenerative braking, etc. are not described in prior art DC motors.
54

55 B. U.S. Patent No. 4,438,362 to Brown March 20, 1984 "Self Starting
56 DC Motor with Permanent Magnets of Varied Magnetic Strength"
57 describes a disk shaped motor with annular magnets in the
58 periphery and a coil in the center with all magnets reacting together
59 as the coil is energized and de-energized. U.S. Patent No. 4,551,645
60 to Takahashi, et al Nov 5, 1985 for "Disk Type Brushless Motor"
61 describes a motor with field magnets of two or more poles and loop-
62 like armature windings in quantities of two or more. It is concerned
63 with not overlapping the armature windings. U.S. Patent No.
64 4,707,645 to Miyao et al Nov 17, 1987 for "Single Phase Brushless
65 Motor" describes a motor, with dual rotors that has six magnets and
66 three non-magnets on the peripheries of the rotors, and a stator with
67 nine coils on it's periphery, providing perfect balance between the
68 nine magnets and non-magnets and the nine coils so that all magnets
69 pass over a coil at exactly the same time in perfect balance.

70 A designed imbalance in the number of magnets and coils which
71 positions adjoining magnets at different degrees of distance from
72 coils ahead and coils behind, and which insures that all magnets do

73 not pass over a coil at exactly the same time is not described in prior
74 art DC motors.

75

76 C. U.S. Patent No. 4,394,594 to Schmider, et al July 19, 1983 for
77 "Motor With a Disk Rotor" describes two groups of "iron-free coils"
78 that are press mounted to the metal casing of the stator, with
79 insulating foil. However, the conductive metal casing is still subject
80 to hysteresis and eddy currents which are electromagnetically
81 induced when the "iron-free coils" are energized, during operation of
82 the "Motor With a Disk Rotor", unlike the said air core coils of the
83 instant invention that utilizes cores of non-conductive non-magnetic
84 material. Also, if a north pole is induced in the Schmider "iron-free
85 coils" with the same current as required in the said air core coils, the
86 "iron-free coils" will not repel the north poles of strong permanent
87 magnets as efficiently as the said air core coils in the applicants
88 invention. Instead strong neodymium magnets will actually attract
89 the conductive metal casing attached to the "iron-free coils" unless
90 more power is added, inefficiently, to the "iron-free coils".

91 Air core coils with cores that are non-conductive or non-
92 magnetic, or coils that are not attached to conductive or magnetic
93 materials, were not described in prior art DC motors.

94

95 D. U.S. Patent No. 4,237,410 to Erickson et al, December 2, 1980
96 "Regenerative Electric Motor" describes a brush type DC motor that
97 uses the voltage from collapsing electromagnetic fields around the
98 armature, inductive kickback, to charge the batteries. And U.S.
99 Patent No. 4,055,789 to Lasater October 25, 1977 for "Battery
100 Operated Motor Switch Back EMF" describes the use of inductive
101 kickback to charge the batteries. U.S. Patent No. 4,785,228 to
102 Goddard November 15, 1988 "Electrical Energy Enhancement
103 Apparatus" describes an apparatus that uses capacitors connected to
104 electromagnets as alternate power sources. As resonance occurs in
105 the energy flow between the capacitors and electromagnets, energy
106 fed back from the electromagnets assists in driving the apparatus.
107 Patent No. 3,890,548 to Gray June 17, 1975 "Pulsed Capacitor
108 Discharge Engine" describes a motor that uses storage batteries and a

109 capacitor bank. The batteries charge the capacitor bank, which
110 discharge through oppositely polled coils to drive, repel, the rotor.
111 Secondary batteries are charged by inductive kickback and with the
112 primary batteries appear to be the power source for the "engine".

113 However, the directing of power through the coils to both pull
114 and push the permanent magnets in the rotors in the same direction
115 is not described in prior art DC motors.

116
117 E. The applicant's DC motor is multiphasic as [1]) it is designed and
118 built with -t-, an integer equal to two or greater, multiple phases and
119 [2]) while operating it can utilize one or more of the multiple phases,
120 depending on the load requirements, [and] as directed by the
121 specially designed microprocessor with proprietary algorithm.

122 Multiphasic DC motors are not described in prior art DC motors.

123 124 SUMMARY OF THE INVENTION 125

126 The subject invention describes a highly efficient pancake shaped
127 multiphasic DC motor with dual flywheel rotors that operates with
128 generator characteristics that simultaneously captures and stores
129 inductive kickback and back emf, in addition to collecting generated
130 power, regenerative braking, etc. RPM, torque, regenerative
131 braking, inductive kickback and back emf are all variable and
132 controlled by a microprocessor and algorithm. Batteries and
133 capacitor banks are used as a rechargeable power pack.

134 At 100 RPM to 3,000 RPM, this high efficiency DC motor with
135 generator and flywheel characteristics has an efficiency of about 80%
136 to 95%.

137 The prototype is about 14 inches in diameter by 3 inches in
138 height with twelve permanent magnets mounted in the periphery of
139 two outer rotor disks and fifteen air core coils in the periphery of an
140 inner stator disk. The magnets are mounted with north and south
141 poles reversed for every other magnet. The air core coils are
142 activated in equilateral positioned groups of three, while pairs of
143 magnets in the outer rotors rotate past the coils. The flywheel rotors

144 operate together as a single parallel unit secured to the central shaft
145 with the stator fixed and sandwiched between the two rotors.

146 The high efficiency multiphasic DC motor, using power from the
147 power pack, is controlled by the specially designed microprocessor,
148 which sequentially pulses the coils in equilateral groups. The dual
149 flywheel rotors develop and store sufficient kinetic energy to
150 provide a smooth output without any torque ripple.

151 With the designed imbalance of 12 magnets and 15 air core coils,
152 some coils are being energized during their motor phase, while
153 simultaneously inductive kickback and back emf are conserved
154 through the intelligent control of the power pack, in addition to
155 which, generated power such as regenerative braking, inductive
156 kickback and back emf are intelligently collected and stored in the
157 power pack at their times of induction. This designed numerical
158 imbalance of 12 magnets and 15 coils insures that adjoining magnets
159 are at different degrees of distance from the coils ahead and the coils
160 behind, and also insures that all magnets do not pass over coils
161 simultaneously.

162 Full wave bridge rectifiers and power switching electronics assist
163 in collecting generated power, such as regenerative braking power,
164 back emf and inductive kickback, which are intelligently stored in
165 the power pack for future use.

166 High efficiency in the DC motor is achieved by the imbalance in
167 the number of 12 permanent magnets pairs and 15 air core coils; the
168 control of the pulling and pushing, attraction and repulsion, of the
169 magnets; the simultaneous conservation of energy by collecting
170 generative power such as inductive kickback and back emf; the
171 multiphasic operation; the dual flywheel rotors, the power pack and
172 the intelligent control provided by the specially designed
173 microprocessor and proprietary algorithm.

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BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 shows a schematic and block diagram of the power electronics, rectifiers, H-bridges, coil connections microprocessor.
- Figure 2 shows a plan view of the positions of twelve magnets, relative to fifteen coils during a period of revolution of the rotors containing the magnets.
- Figure 3 shows a conceptual cut-away view of the stator and the dual flywheel rotors, with the relative positions of the coils and magnets, plus a sectional view of the stator and the dual rotors.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figure 1, the high efficiency multiphasic DC motor is a pancake shaped high efficiency DC motor with dual flywheel rotors that operates with generator characteristics that simultaneously captures and stores inductive kickback and back emf, in addition to collecting generated power, regenerative braking, etc. RPM and torque are both variable and controlled by the microprocessor 1. The high efficiency DC motor uses a power pack 2 as a rechargeable power source, which is composed of a capacitor bank and batteries. At normal operating speeds of about 100 RPM to 3,000 RPM the motor has an efficiency of about 80% to 95%.

Referring to Figure 2 and 3, the preferred embodiment of the high efficiency DC motor is composed of one stator 4, containing the coils, that is fixed to a stationary housing; sandwiched between dual disk shaped flywheel rotors 3, containing the magnets, that are mounted on a central shaft 5 and operate together as single parallel unit.

The high efficiency DC motor, in its preferred embodiment, has twelve pairs of one inch diameter by three-quarters inch high magnets 6, mounted equidistant apart in the periphery of the two rotors, with north and south poles reversed for every other magnet. There are fifteen coils 7, with 1 inch diameter air cores 8, also

216 mounted equidistant apart in the periphery of the stator. The
217 difference in the number of magnets and coils provides a designed
218 imbalance so that adjoining magnets are positioned at different
219 degrees of distance from coils ahead and coils behind and insuring
220 that all magnets do not pass over coils simultaneously.

221 In the preferred embodiment of the high efficiency DC motor,
222 permanent magnets 6 are made of neodymium (NdFeB) and the air
223 core coils 7 are wound with wire of high conductivity. When a north
224 pole is induced in an air core coil 7, it will efficiently repel the north
225 pole of the neodymium magnet 6 as the magnet passes over the
226 energized air core coil 7. However, if the coil contained an iron core
227 and was energized with same amount of power as used to energize
228 an air core coil 7, the north pole of a neodymium magnet 6 will
229 attract the iron core of the coil, even though it has an induced north
230 pole. Only by increasing the power to the iron cored coil will the
231 neodymium magnet be repulsed. This is an inefficient use of power.

232 The high efficiency multiphasic DC motor also has certain
233 generator characteristics. It induces, captures and stores inductive
234 kickback and back emf, as well as collecting generated power such as
235 regenerative braking. During any degree of rotation of the rotors,
236 one or more groups of magnets 6 are approaching or departing de-
237 energized coils 7. This induces electron flow in the de-energized coils
238 7, generating electric power at a lower power level than the
239 energized coils 7 operating in a motor phase, providing controlled
240 regeneration and storage of regenerative braking, back emf and
241 inductive kickback at their respective times of induction.

242 Referring again to Figure 1, the operation of the high efficiency
243 multiphasic DC motor is controlled by a specially designed
244 microprocessor 1, an absolute position encoder 1a, sensors 9a and 9b
245 and power electronics 10a and 10b in a manner well known to those
246 skilled in the art. The coils 7 are sequentially energized or pulsed,
247 through the motor H-bridges, by the microprocessor 1 in the proper
248 order and polarity. Generated power and inductive kickback are
249 collected by full wave bridge rectifiers 11 plus power electronics and
250 stored in the power pack 2. This power is later fed sequentially

251 through H-bridges 12 into air core coils 7, being energized for their
252 motor phase.

253 The motor is also designed to utilize a dual flywheel rotor that
254 will develop and store enough kinetic energy to provide high torque
255 output and inertia to sustain, smooth out and hold the RPM
256 developed by the rotors. The flywheel design of the disk shaped
257 rotors plus the weight of the magnets 6 in the periphery of the rotors
258 provides adequate mass to store kinetic energy.

259 This invention has been described in terms of a preferred
260 embodiment. However, those skilled in the art know that it is
261 possible to make many changes and that other embodiments are
262 possible without departing from the spirit of the high efficiency
263 multiphasic DC motor invention and its various designs. For example:

264 A. With design changes in the magnets, coils, microprocessor,
265 power pack and DC motor dimensions, speeds of 25,000 RPM and
266 much higher are possible.

267 B. The high efficiency DC motor will also operate using a single
268 rotor sandwiched between two stators.

269 C. Additional high efficiency DC motor modules (one stator and
270 dual rotor per module) or stages (one rotor and one stator per stage)
271 may be added to increase electrical power and kinetic energy.

272 D. Electromagnetic coils can be used instead of permanent
273 magnets.

274 E. The dimensions, weight and shape of the high efficiency DC
275 motors, its magnets and its coils are all variable. They can vary from
276 a fraction of inches to many feet and from a fraction of ounces to
277 hundreds of pounds and they can be used in a variety of shapes.

278 F. The high efficiency DC motors will operate if the north and
279 south pole pairs of the permanent magnets are not aligned in the
280 same polarity or if the polarity is not reversed for every other
281 magnet pair.

282 G. The number of magnets and coils used can be reversed,
283 increased, decreased or varied, depending on design requirements.

284 H. The magnets can be made of iron, conductive materials or
285 super conductors, as can the coils. The coils can be wire wound,

286 ribbon wound or solid state. Rectifying devices other than full wave
287 bridge rectifiers can also be utilized.

288 I. Additional magnets can also be mounted on the radii of the 12
289 magnets in the periphery of the rotors, and more coils can be added
290 on the radii of the 15 coils in the periphery of the stator. This will
291 increase both the kinetic energy and the electromagnetic power of
292 the high efficiency DC motor.

293 J. With all the magnets of the radii coupled together with iron or
294 other amorphous metals, both the electric power and kinetic energy
295 of the high efficiency DC motor will increase markedly.

296 K. The high efficiency DC motor will also operate with other
297 groupings of magnets and coils, such as 1, 2, 5. etc.

298 L. The high efficiency DC motor system can utilize advanced chip
299 designs that are not currently available; can use miniaturized and/or
300 combined electronic components; and can use remote control, while
301 retaining the basis of a highly coordinated DC motor system.

302 M. When capacitors with battery characteristics and/or batteries
303 with capacitor characteristics become available; the power pack may
304 then be modified to utilize these devices. For example, there are
305 5000 volt 70 farad capacitors currently in the development stage
306 that may be utilized by the HEFO power pack when available.

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CLAIMS

We claim:

1. A high efficiency, high torque multiphase direct current machine which operates simultaneously in a motor-mode, in a generator-mode, and in a flywheel-mode comprising:

an inner stator disk, with one or more air core coils mounted equidistant apart in a periphery of said stator disk and positioned so that said air core coils are energized in equilaterally balanced groups;

a pair of outer rotor disks disposed parallel to and aligned with one another;

said stator disk and said rotor disks being made of strong lightweight plastic structural materials;

a fixed central shaft coupled to said rotor disks and passing through said stator disk, where said shaft is sandwiched in a fixed position between said rotor disks;

a plurality of permanent magnets arranged in two paired sets, said magnets of each one set are mounted equidistant apart in a periphery of each one rotor disk, with each pair in polar alignment and poles of each pair reversed in every other pair;

a generated current sensor and a generated voltage sensor for use in generator-mode;

a current consumption sensor and a voltage consumption sensor for use in motor-mode;

a rotor position sensor;

a switching means for controlling power to said coils;

358

359 a feedback controlled rectifying means to recover and control
360 generated energy;

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362 a rechargeable power pack including electronically controlled
363 rectifying devices, driver electronics, a capacitor bank, and
364 rechargeable batteries, where said machine concomitantly in
365 generator-mode utilizes inductive kickback, back-emf, and
366 regenerative braking to recharge said power pack; and,

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368 a microprocessor controlling electronic commutation and
369 operation of said machine by utilizing data derived from said
370 sensors.

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373 2. The multiphase machine as claimed in claim 1, wherein said
374 machine includes one or more phases, and wherein some of said one
375 or more phases are selected to operate in said motor-mode while
376 simultaneously the other of said one or more phases are selected to
377 operate in said generator-mode, and said permanent magnets in said
378 rotor disk periphery combine to produce a flywheel rotor mass
379 which provides kinetic energy to said machine in said flywheel-
380 mode.

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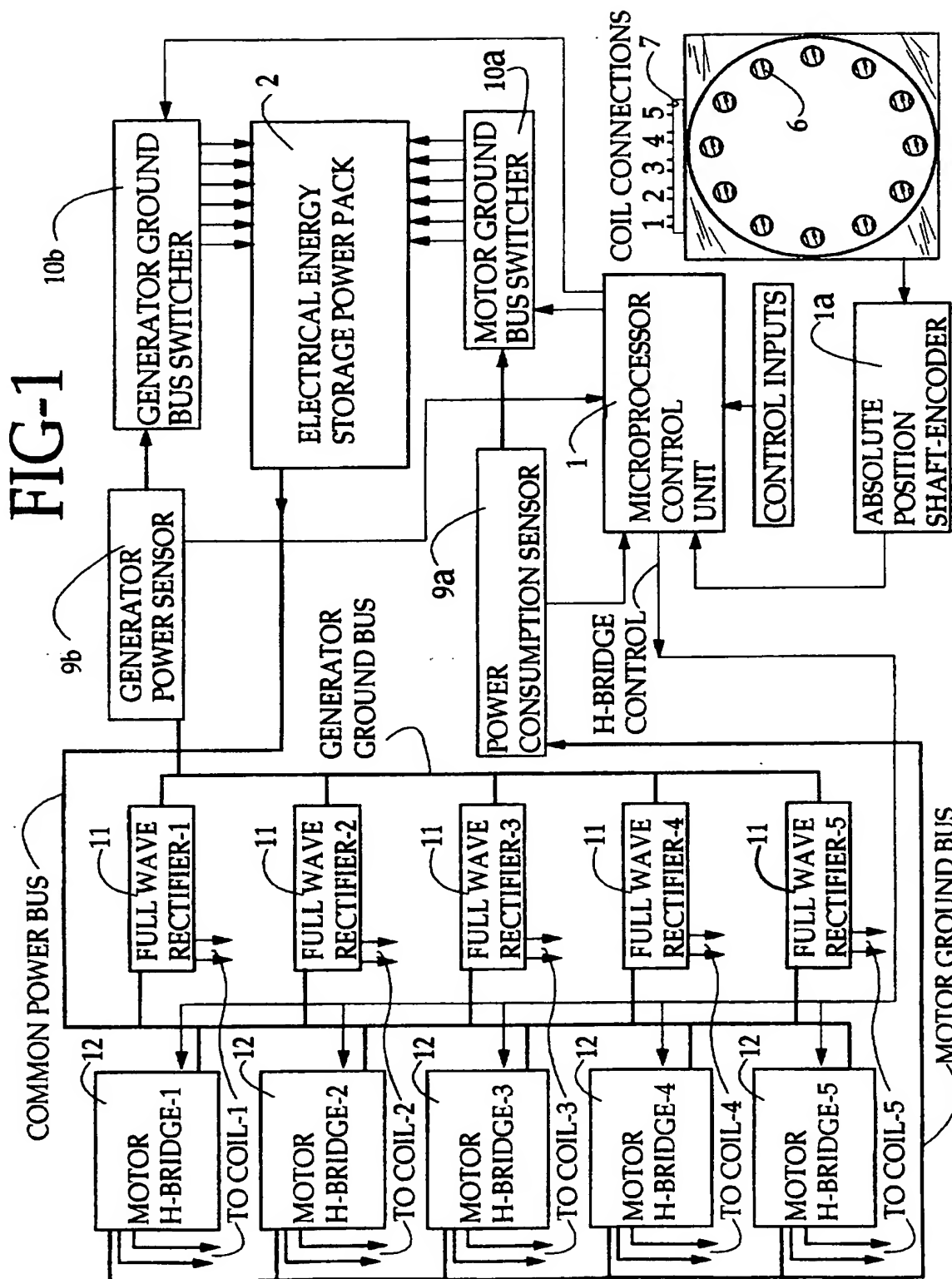
383 3. The multiphase machine as claimed in claim 2, wherein said one
384 or more phases of said machine comprises five separate phases
385 incorporated into five groups of three said air core coils each, for a
386 total of three said air core coils each, for a total of fifteen coils, where
387 said total of fifteen coils are mounted equidistant apart on said
388 periphery of said stator disk in five equilaterally positioned groups
389 of three.

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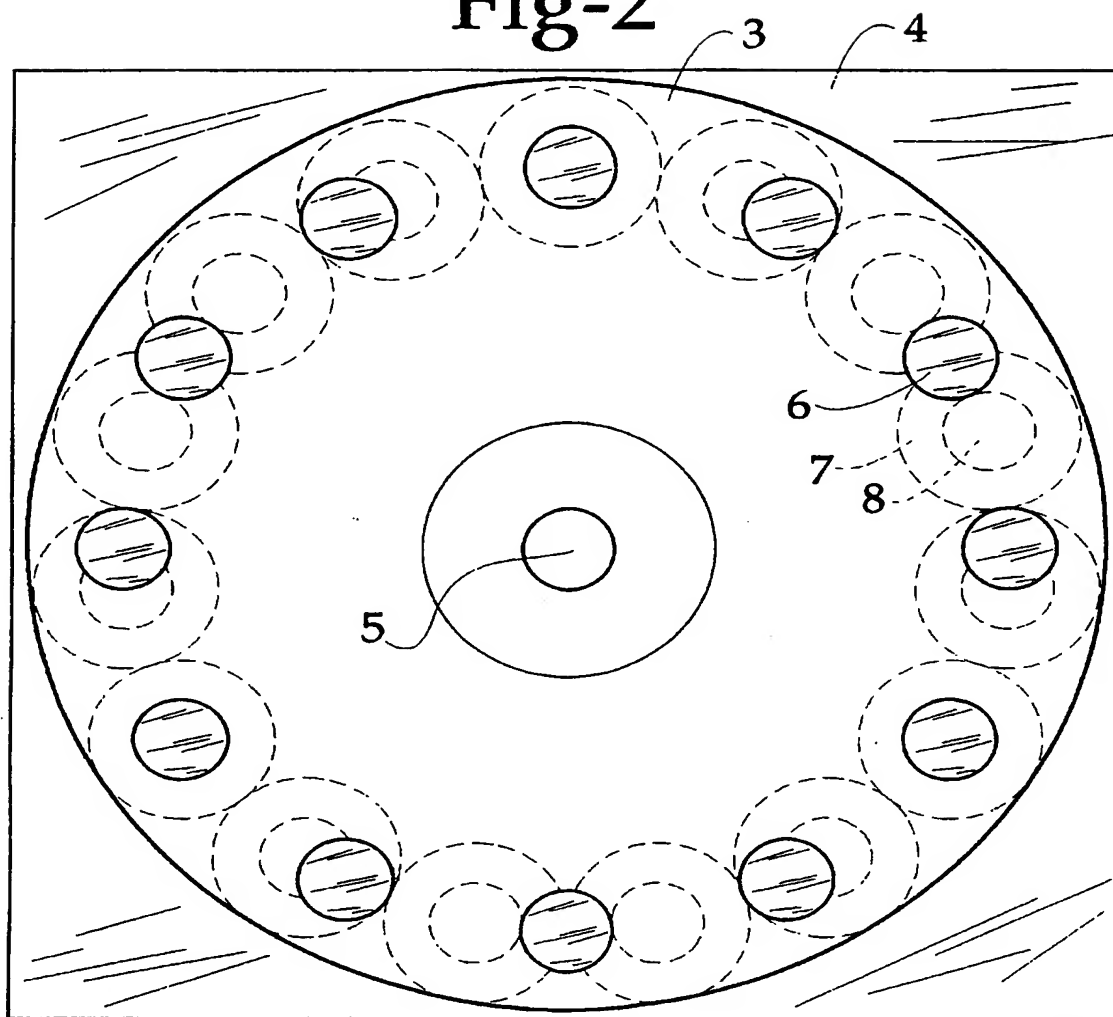
392 4. The multiphase machine as claimed in claim 1, wherein said air
393 core coils include cores with no magnetic material contained therein,
394 and said cores produce little or no hysteresis or eddy current.
395

396 5. The multiphase machine as claimed in claim 1, wherein said
397 plurality of permanent magnets in said rotor disks comprises
398 twenty-four neodymium magnets in twelve pairs, where said twelve
399 pairs are mounted in polar alignment and equidistant apart in said
400 peripheries of said disks with north and south poles reversed in
401 every other pair.
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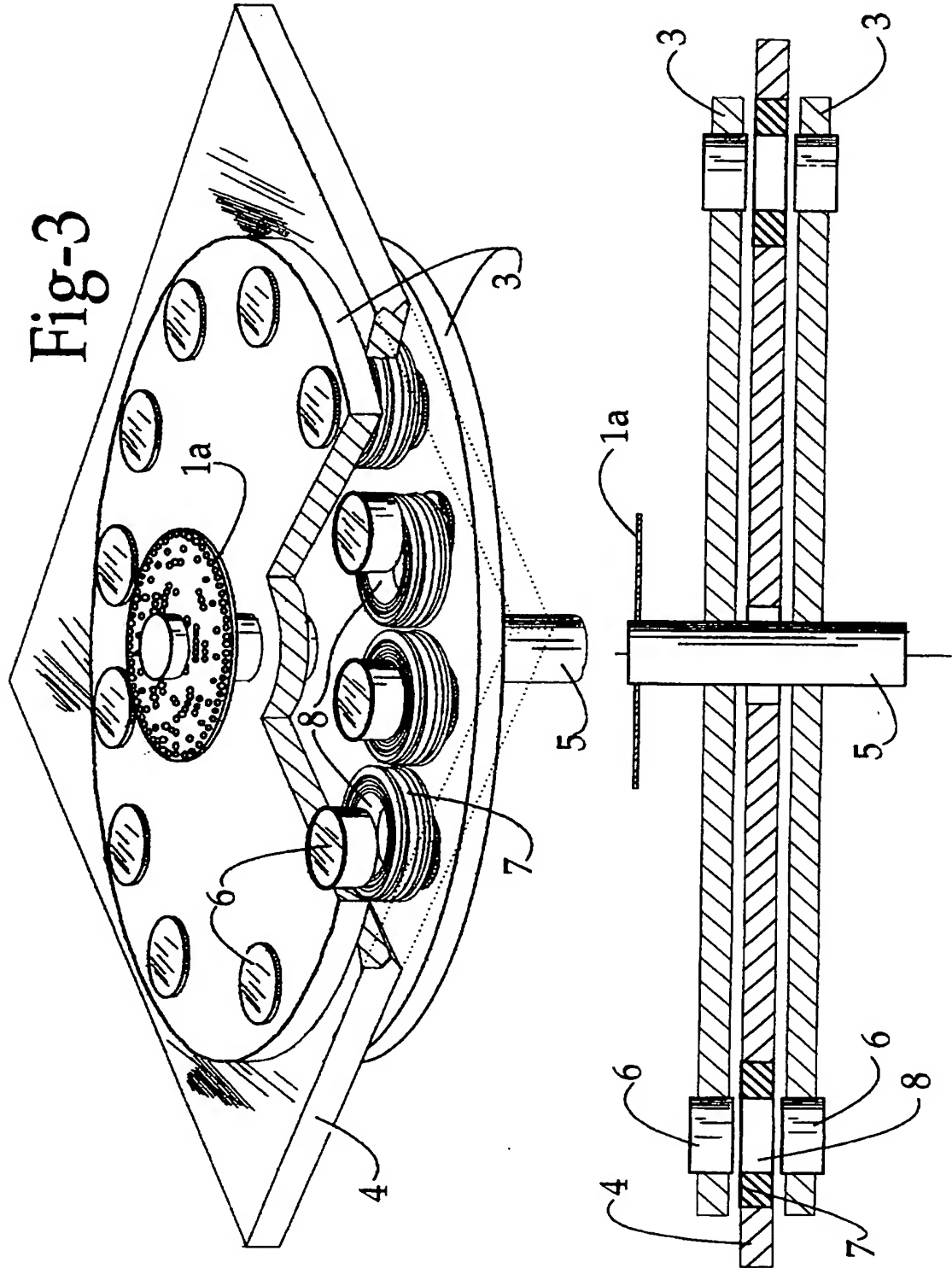
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Fig-2



3/3

Fig-3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/17031**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : H02K 23/00

US CL : 318/254, 138, 439, 150, 139, 161; 310/74, 40R, 177, 261, 268

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 318/254, 138, 439, 150, 139, 161; 310/74, 40R, 177, 261, 268

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 5451881 (Finger) 19 September 1995	

☐ Further documents are listed in the continuation of Box C.
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* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed		"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "Z" document member of the same patent family
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Date of the actual completion of the international search

18 MARCH 1996

Date of mailing of the international search report

23 APR 1996

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